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Climate: A Database of Temperature and Salinity Observations for the Northwest Atlantic

Climate : Une base de données d'observations de la température et de la salinité pour le nord-ouest de l'Atlantique

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Abstract

The Ocean Science hydrographic database (Climate) is a comprehensive, open access collection of temperature and salinity data for the Northwest Atlantic and Eastern Arctic, an area defined by 35°N - 80° N and 42°W - 100° W. The data come from a variety of sources including hydrographic bottles, CTD casts, profiling floats, spatially and temporally averaged Batfish tows, and expendable, digital or mechanical bathythermographs. Near real-time observations of temperature and salinity from the Global Telecommunications System (GTS) are also included. The database currently consists of approximately 630,000 profiles and 30 million individual observations from 1910 to the present. Vertical resolution varies from 1 m (for CTDs) to ~ 10-100 m for traditional bottle casts. Climate is updated monthly and approximately 20,000 new profiles are added each year.

The database can be accessed at the web address:
http://www.mar.dfo-mpo.gc.ca/science/ocean/database/data_query.html.

Résumé

La base de données hydrographique des science océanologiques (Climate) est une imposante collection de données librement accessibles sur la température et la salinité pour le nord-ouest de l'Atlantique et l'Arctique oriental, la région définie par les coordonnées 35° N à 80° N et 42° O à 100° O. Les données ont diverses provenances, bouteilles hydrographiques, sondes CTD, flotteurs profileurs, moyennes spatiales et temporelles de données de sondes remorquées Batfish et données de bathythermographes numériques ou mécaniques non récupérables. Elle regroupe en outre des observations en temps quasi-réel de la température et de la salinité du Système global de télécommunications (SGT). La base de données renferme actuellement environ 630 000 profils et 30 millions d'observations individuelles datant de 1910 à aujourd'hui. La résolution suivant la verticale varie de 1 m (pour les CTD) à environ 10 à 100 m pour les classiques sondages au moyen de bouteilles. La base de données Climate est mise à jour tous les mois et environ 20 000 nouveaux profils sont ajoutés chaque année.

La base de données peut être consultée à l'adresse Web :
http://www.mar.dfo-mpo.gc.ca/science/ocean/database/data_query_f.html.

Introduction

The development of the hydrographic database named Climate began in 1991 as a project under the Atlantic Fisheries Adjustment Program (AFAP). Initially confined to the Gulf of Maine, the boundaries were extended in stages to their present limits (35-80°N, 42-100°W), shown in Figure 1. The database and supporting application software have migrated through a number of computer operating systems and database architectures since initially conceived, but the original objective of providing a comprehensive, open access database of hydrographic observations has remained unchanged.

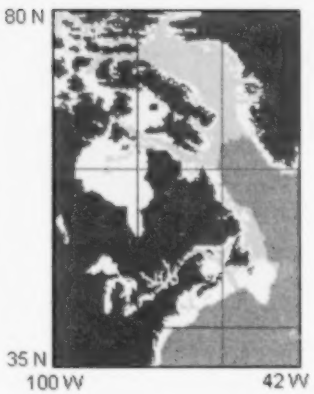

Figure 1 Climate boundaries

Source Data

Data for the Climate database are provided by the Marine Environmental Data Service (MEDS)[1], the oceanographic data center for Canada's federal Department of Fisheries and Oceans (DFO). Part of MEDS mandate is to manage and archive ocean data collected by DFO and other national and international programs conducted in ocean areas adjacent to Canada. Through international data exchange agreements, the Climate database includes oceanographic observations from other national data centers, such as the U. S. National Ocean Data Center, with holdings from the target area. Near real-time data are obtained by MEDS as JCOMM BATHY/TESAC[2] messages.

The data originate from a number of instruments including CTD and Batfish, profiling floats, hydrographic bottles and a variety of bathythermographs. Profiles are identified by a data source code as follows:

Code	Date Type and Description
BA	BATHY Message - near real-time low resolution temperature observations (XBT, BT etc.) from the Global Telecommunications System (GTS)
BF	Batfish CTD - CTD mounted on a towed Batfish. Composite profiles are created from spatial and temporal averages
BO	Bottle - any type of sample bottle (salinity and temperature if equipped with thermometer)
CD	CTD down trace (salinity and temperature)
CU	CTD up trace (salinity and temperature)
DT	Digital Bathythermograph (temperature)
MB	Mechanical Bathythermograph (temperature)
ML	Minilog temperature recorder – generally trawl mounted (temperature)
PF	Delayed mode profiling float data. Most floats report both temperature and salinity.
TE	TESAC message - near real-time low resolution observations from the Global Telecommunications System (GTS) (salinity and temperature)
TO	Towed CTD - Also sometimes called a Yoyo CTD. The instrument is repeatedly lowered and raised while the ship is underway
XB	Expendable Bathythermograph (temperature)

The database is updated monthly. As a result of data archeological efforts at many research institutions, monthly updates do not only contain recent data, but frequently include major additions from observations made years or even decades earlier. As of April 2004, the database contained over 630,000 profiles with 30 million individual observations from 1910 to the present. About 20,000 new profiles are added each year.

The following two figures provide an indication of the spatial and temporal extents of the data. Figure 2 shows the seasonal distribution of stations which recorded both temperature and salinity between 20 and 40 metres. This depth range was chosen to exclude the large number of stations having surface observation only. As to be expected, the number of profiles in the fall and winter is comparatively low (30,000 – 40,000 profiles) and almost non-existent in the north. Spring and summer (70,000 – 80,000 profiles) has better (but limited) coverage in the Arctic and Hudson Bay.

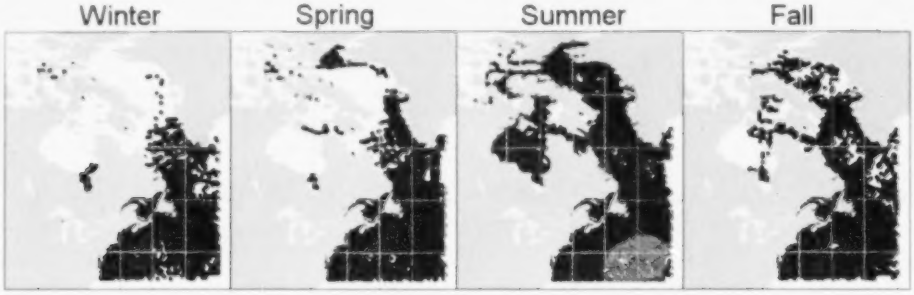

Figure 2 Location of stations with both temperature and salinity observations between 20 and 50m

Figure 3 shows the count of observations from all stations separated into three depth ranges. The dark bars represent temperature and the lighter colored bars show salinity.

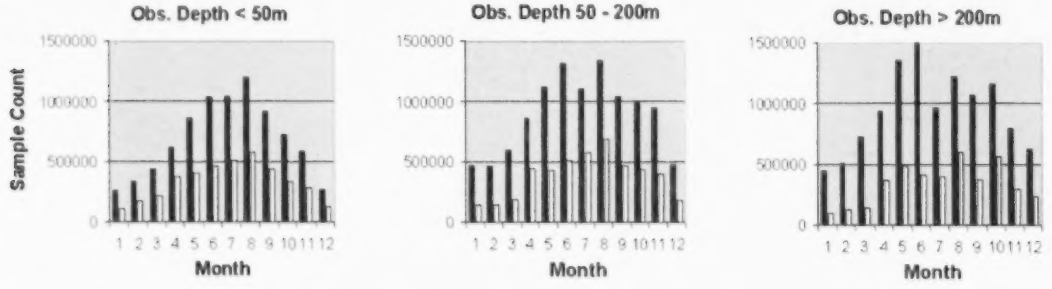

Figure 3 Number of T and S Observations by Depth

Almost 60% of the data are from a variety of bathythermographs which only record temperature. The remaining data are approximately divided between water bottles and CTD instruments. The bottle observations are primarily at standard

oceanographic depths*. The CTD data have a vertical resolution of between 1 – 5 metres. Any CTD data received from MEDS at a vertical resolution higher than 1 metre are bin-averaged to 1 metre resolution. Old style mechanical bathythermographs are generally at standard depths. Expendable bathythermographs (XBT) have a vertical resolution between 1 – 5 metres.

Data Validation

It is assumed that the originating institute or organization carried out initial validation. All data, whether from Canadian or foreign sources, are further quality controlled by MEDS. The primary validation procedures used by MEDS are originally described in the IOC publication GTSPP Real Time Quality Control Manual (UNESCO 1990)[3]. A revised version is maintained on line at http://www.meds-sdmm.dfo-mpo.gc.ca/ALPHAPRO/gtspp/qcmans/MG22/guide22_e.htm[4]. The data are subjected to a suite of twenty-five tests that include checking dates, time between stations, position on land, density inversions, comparison with bathymetry and global climatologies.

Climate is intended as a product database in contrast to a data archive, a service already provided by MEDS. To keep the database as simple as possible, the meta-data are pared to the essential minimum which includes latitude, longitude, profile date/time and data type. A MEDS assigned cruise identifier provides a pathway back to the source data if required.

At the Bedford Institute, the data are subjected to further tests before being incorporated into the database. One of the primary functions of this validation is the determination and elimination of duplicate profiles. For climatological purposes, a duplicate is defined as any profile that is within 0.02° of latitude and 0.03° of longitude (roughly 3 km) and 30 minutes time of another profile. Determining which duplicate to select is based on a data type hierarchy. A CTD down cast is at the highest level, down through bottle casts, the various BT types, and finally the low resolution JCOMM TESAC and BATHY data. BATHY and TESAC data are replaced with the higher resolution data as they become available from the originating institute, a process that may take a number of years. If data type does not reconcile a duplicate, decisions are based on a progression of selecting

* Oceanographic measurements have traditionally been taken at standard "nominal" depths, based on the wire length let out from the ship to suspend the instrument. It was understood that the "nominal" depth was probably inaccurate due to wire angle from currents.

Standard Oceanographic Depths					
Start	**End**	**Increment**	**Start**	**End**	**Increment**
0	30	10	400	1400	100
50	150	25	1500	2000	250
200	300	50	2000	9000	500

Canadian data over foreign, selecting the profile with the greatest number of observations, and finally, selecting the profile with the greatest depth. The net result of the duplicate checking is to flag profiles as 'new' (not in the database), 'replace' (a better version than what is in the database), and 'discard' (a better version is already in the database).

Profiles that pass the duplicate checking are subjected to an on-land check that has a finer geographical resolution than the one used by MEDS. Profiles passing this test are examined for MEDS QC flags. Those profiles without any failure flags are entered into the database without further assessment. Profiles that have been flagged as having failed the MEDS QC are individually examined to determine if any may be salvaged. There is no attempt to correct erroneous data, however individual points may be discarded and a portion of a profile retained.

In addition, the entire database is subjected to ongoing subjective and objective tests to improve the overall confidence in the data. Stations with individual temperature or salinity observations 3 standard deviations outside the mean value derived from a 1° grid monthly averaged over depth ranges varying from 25 meters at the surface to 500 meters for the deep ocean have been individually examined and removed when deemed appropriate. Temperature-salinity curves are not examined as part of the quality control procedure. Our users have also been another valuable source of quality control, identifying and reporting data that they believe should be re-examined.

During the early 1970s, data were sent to MEDS from BIO at a reduced resolution based on a linear regression tolerance of 0.01°C or 0.01 psu. Also during the period 1969-89, MEDS had a limit of 99 levels for a single CTD profile, which they ensured by using a similar reduction technique. As a consequence, much of the CTD data from this period were at a much-reduced vertical resolution. As a one-time adjustment to the Climate database, all CTD data prior to 1990 with an average depth resolution (maximum depth / # of observations) of less than 5 meters were interpolated to include values at standard oceanographic depths. This ensures that CTD data are represented in the database at a resolution at least as detailed as bottle observations.

Data Access

Data in the Climate database are freely available to anyone wishing access. Up-to-date details and access to the database can be found at the Ocean Science web site[5] http://www.ma[illegible]-mpo.gc.ca/science/ocean/database/data_query.html.

Because the query application is constantly undergoing enhancements in response to user requests, a detailed description of the application is not provided. Some of the features include the following:

The use of the Climate database requires a one-time registration. Climate, as well as other Ocean Science applications, performs the data extraction as a batch process after a query has been submitted. Registration is necessary to provide a contact email address to inform the user when query results are available. Registration permits access to Climate and other Ocean Science databases. Other databases include monthly current statistics for current measurements in the BIO archive (ODI), weekly sea-surface temperature observations from NOAA satellites (SST) and daily temperature observations for moored thermographs in the BIO archive (CTS). A description of all the databases available is also provided at the Ocean Science web site[5]:
http://www.mar.dfo-mpo.gc.ca/science/ocean/database/data_query.html.

Users can specify spatial and temporal criteria with latitude/longitude ranges, user or system-defined polygons, multiple depth ranges, and time windowing options.

Queries are saved and can be edited and re-submitted at any time.

Processing options include the ability to select only those records that contain both temperature and salinity observations and an option to average the values within a profile according to the depth specification. This reduces the resolution of highly sampled data to more closely resemble observations sampled much less frequently.

Users can request a number of different data products which include a station index of latitude, longitude and date/time for each profile selected, individual observations making up the profile, time series based on monthly averages within the latitude, longitude, depth volume, or a seasonal cycle based on averages over all months from the time series statistics.

Clients and Applications

Since the release of the Climate application in 1999, four hundred and eighty users have registered, with about 8 new users each month. The database was originally developed for DFO scientists; however we have found that over 60% of our users are external to DFO. Educational users (primarily universities) account for 30% of the clients. Environmental consultants in the private sector account for a further 15%. Many of the users, such as graduate students, will only use the database for short period of time. We currently have about 150 active users based on using the application at least once within the past 6 months.

Within DFO, the database has been particularly useful in creating shelf wide climatologies at monthly, seasonal or annual scales and in determining initial conditions for numerical models. These climatologies are available on-line at http://www.mar.dfo-mpo.gc.ca/science/ocean/tsdata.html

Acknowledgements

All of the data in Climate are provided from the archives maintained by the DFO Marine Environmental Data Service. This application would not exist without MEDS providing the data exchange, archival and quality control infrastructure. The original AFAP database was developed in 1991 by Roger Pettipas and many of the rules developed by Roger through trial and error are still in use today. The present application was developed and continues to be improved by Science Informatics at BIO. The database content is updated and maintained by a number of individuals within the Ocean Science data analysis group. Finally, the author is very grateful for the many individuals in the oceanographic community that have used the data and provided comments on how the service can be improved.

References

[1]Department of Fisheries and Oceans, Marine Environmental Data Service web site: http://www.meds-sdmm.dfo-mpo.gc.ca/

[2] Department of Fisheries and Oceans, Marine Environmental Data Service web site, Joint Commission on Oceanography and Marine Meteorology: http://www.meds-sdmm.dfo-mpo.gc.ca/meds/Prog_Int/J-COMM/J-COMM_e.htm

[3] UNESCO, 1990. GTSPP Real-time Quality Control Manual, Intergovernment Oceanographic Commission, Manuals and Guides, No. 22.

[4] Department of Fisheries and Oceans, Marine Environmental Data Service web site, Manuals and Guides #22, GTSPP Real-time Quality Control Manual: http://www.meds-sdmm.dfo-mpo.gc.ca/ALPHAPRO/gtspp/qcmans/MG22/guide22_e.htm

[5] Department of Fisheries and Oceans Maritimes Region, Ocean Sciences Division, Oceanographic Databases Web site: http://www.mar.dfo-mpo.gc.ca/science/ocean/database/data_query.html